

Models for Environmentally Sound and Economically Viable Carbon Dioxide Sequestration Opportunities

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Kansas Approach

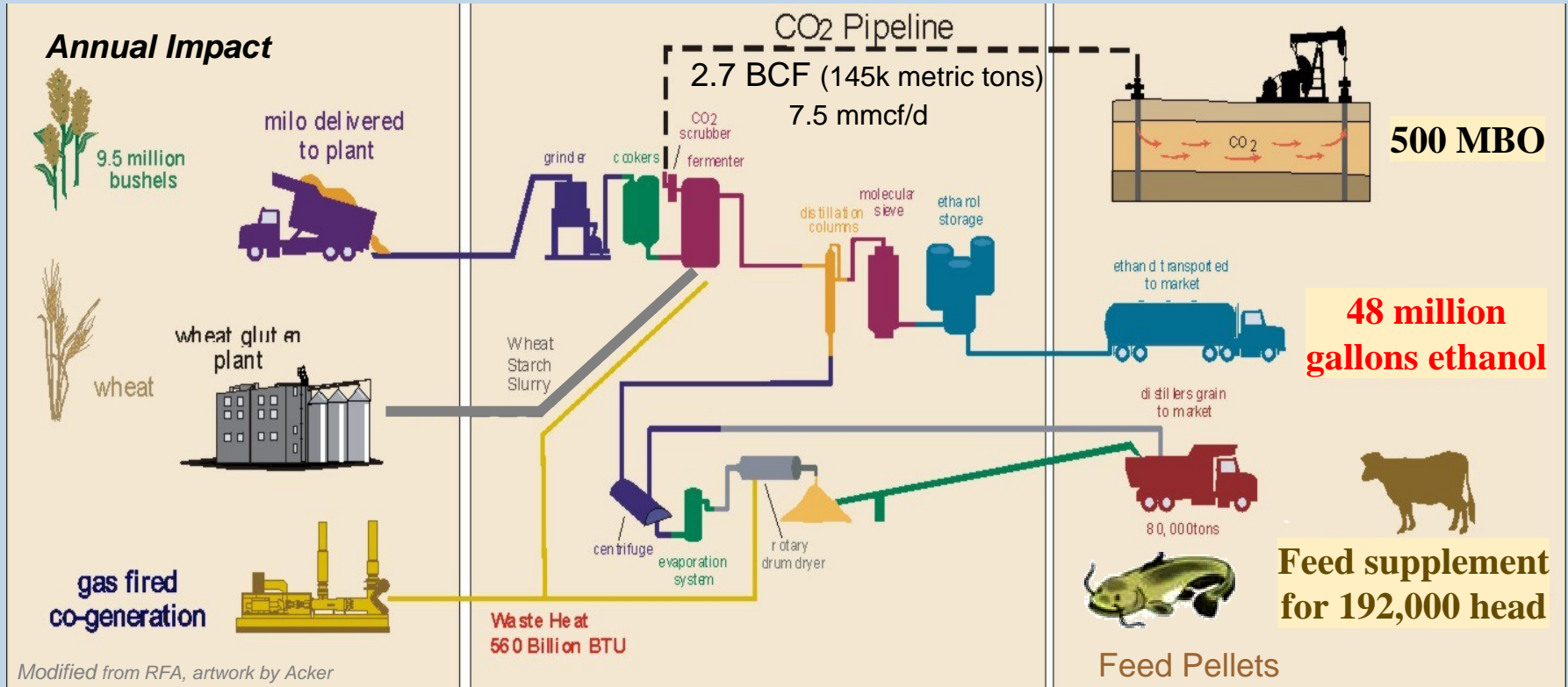
- Inventory & Evaluate Greenhouse Gas Resources
 - Multiple Scales (Nation – Regional – Local – Single Source)
- Inventory & Evaluate Sequestration Opportunities
 - Multiple Scales (Nation – Regional – Local – Wellbore)
- Guiding Principles
 - Economically Viable
 - Environmentally Sound
- Integrated Energy Systems
 - Ethanol Plants
 - Landfills
 - Cement Kilns
- Viewing CO₂ as a Resource
 - Path to the Future

Integrated Energy Systems

Raw Materials

Ethanol Plant

Products



$$1 \text{ metric ton CO}_2 = 19 \text{ mcf}$$

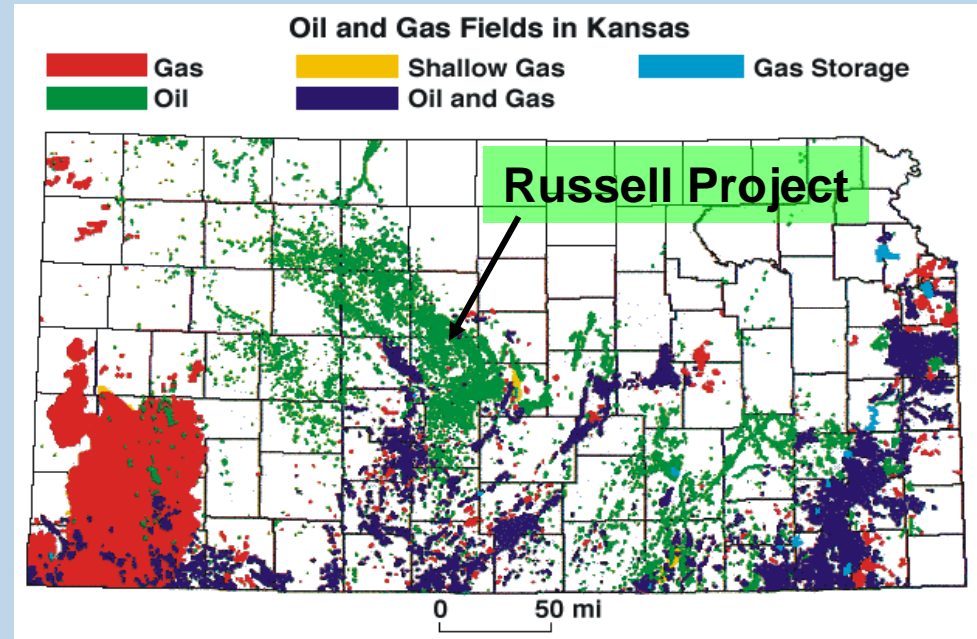
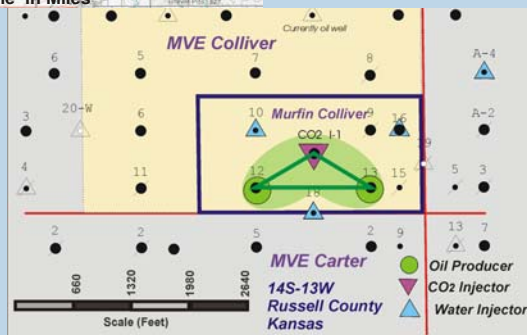
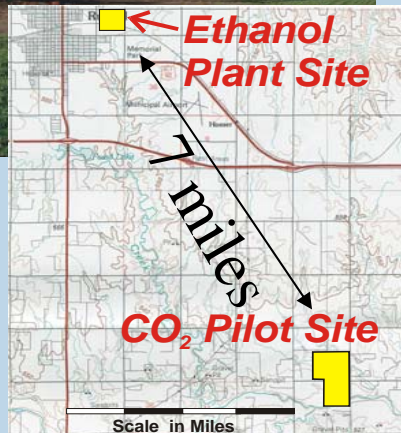
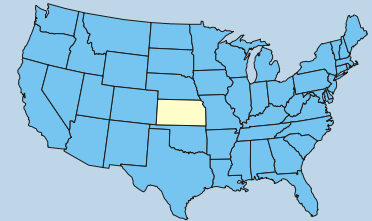


Russell, Kansas Project

USEP Ethanol Plant



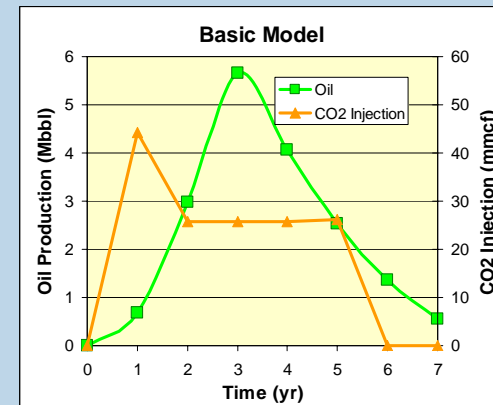
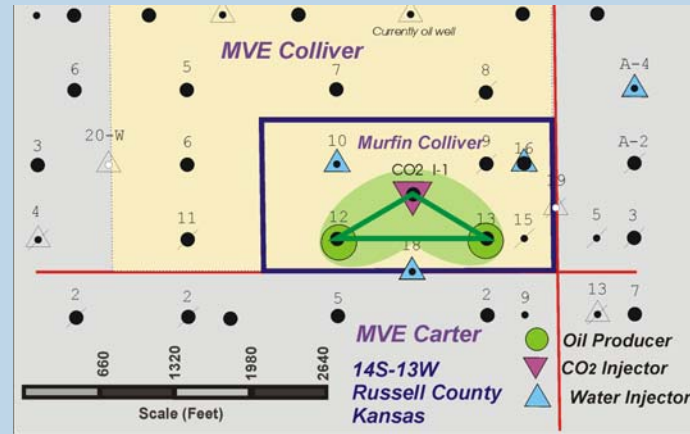
First Sequestration
of Agricultural CO₂



Russell is centered in oil,
grain and cattle region

CO₂ Miscible Flood Demonstration

- 10+ acre, three-spot
- 1 CO₂ injector
- 2 Producers
- 1 Monitoring
- 2 Containment Water Injectors
- 0.29 BCF CO₂ injected-WAG
- 6 year operating life
- 18,000 BO estimated recovery

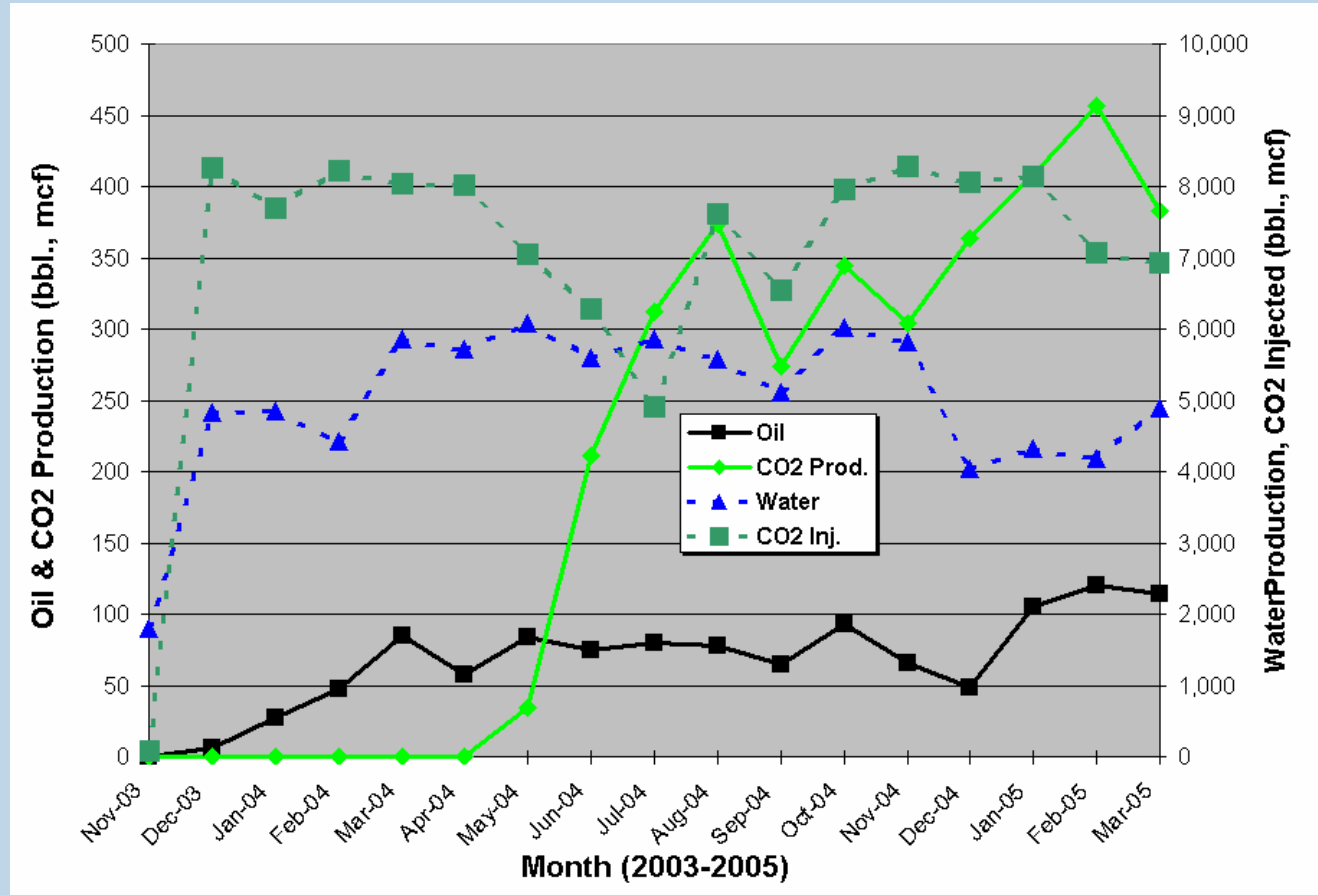


Liquid CO₂ now being supplied by USEP ethanol plant 7 miles away in Russell, KS

www.kgs.ku.edu/ERC/CO2Pilot

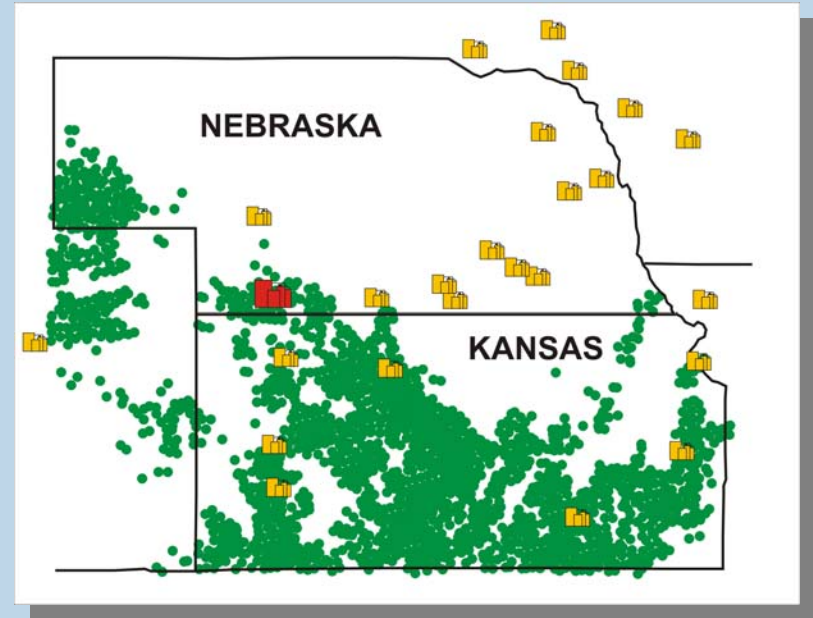
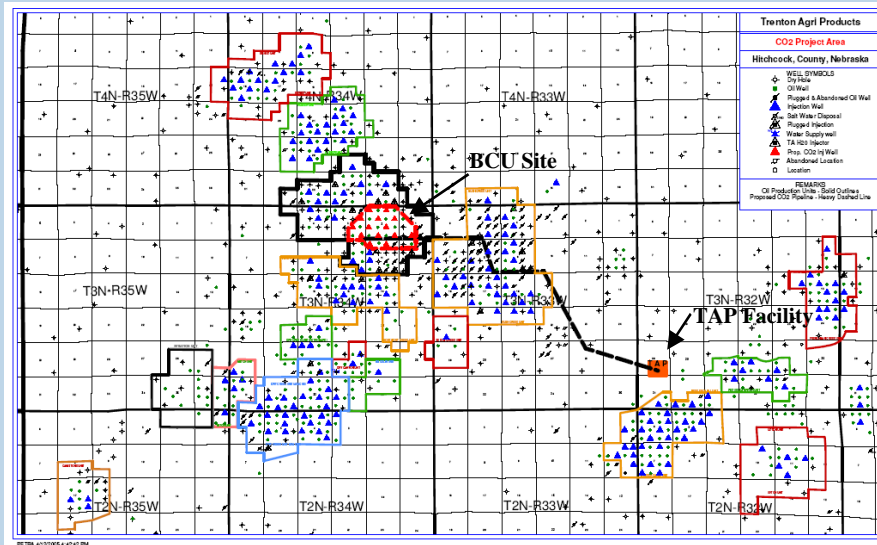
CO₂ Miscible Flood Demonstration

- CO₂ injection began December 2003
- Injection
 - 89 mmcf CO₂ (~34% PPV)
 - 137 Mbbl Water
- Production
 - 1,225 bbl Oil
 - 87 Mbbl Water
 - 3.7 mmcf CO₂

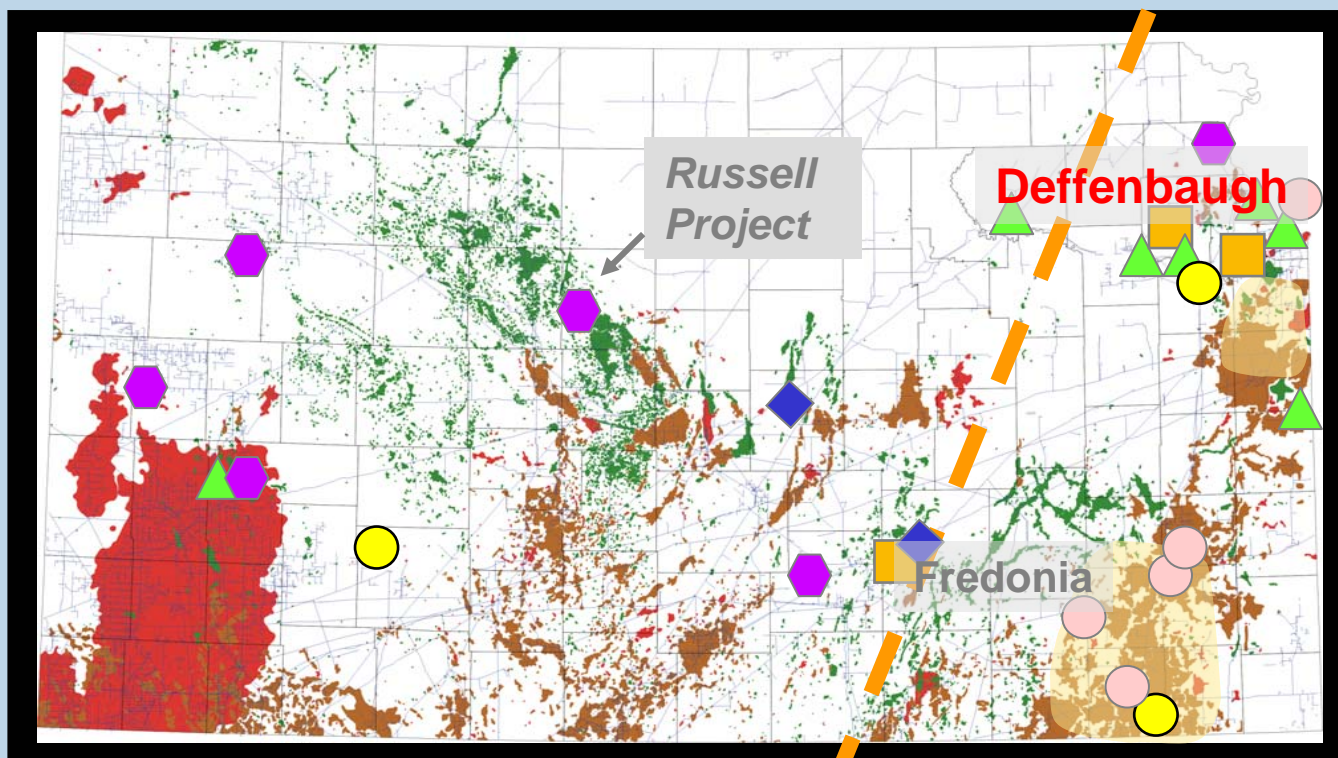


Trenton, NE - Field Demonstration

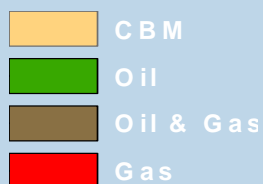
- 14 CO₂ injection Wells - 16 Producers
- 36 → 45 MGY of Ethanol
 - 17 Million Bushels of Corn & Milo
 - 137 metric tons (Mt) DDG
 - 172,000 Head of Cattle
- 300 → 375 Mt/day (5.6 → 7.0 mmcf/d)
- Verification and Carbon Credits



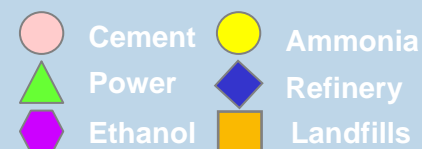
Major Kansas GHG Sources



**Oil and
Gas
Fields**



Industry



Landfill Gas

Landfill Gas (LFG)

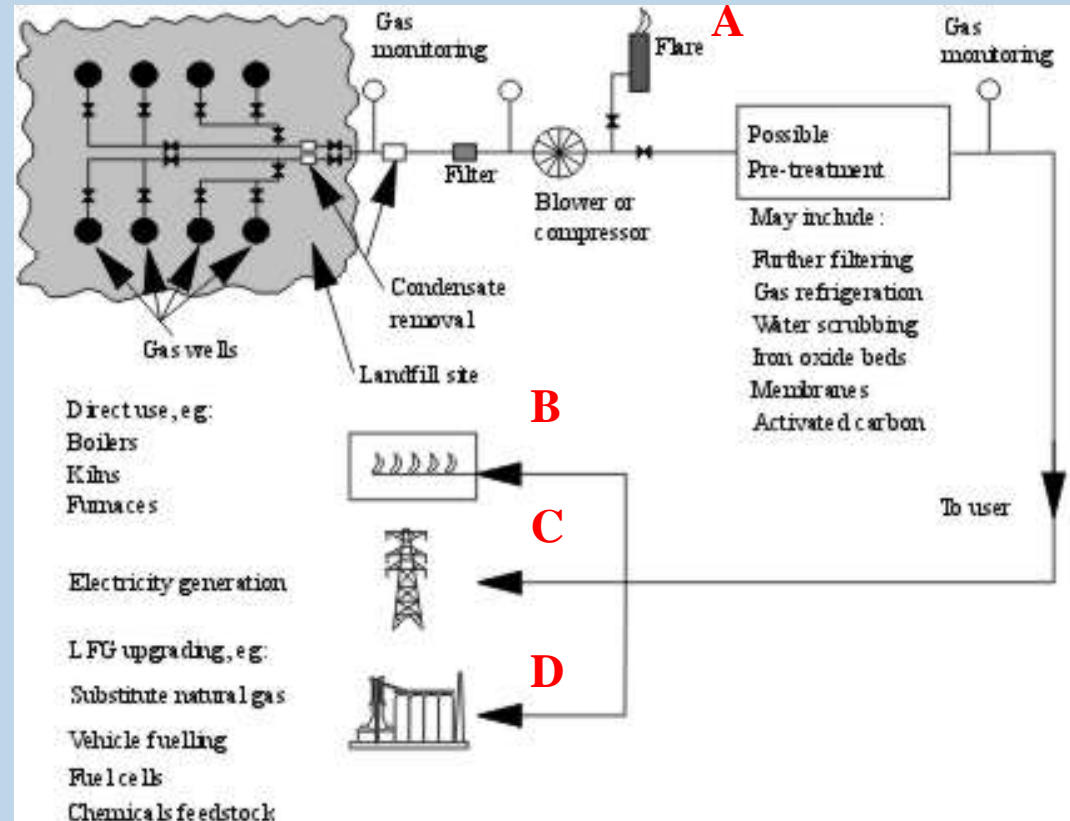
- ★ 9.3 % US Greenhouse Gas Emissions
- ★ 8.1 Million Metric Tons CH₄
 - 4.9 Million Captured
 - 2.4 Million Flared
- ★ \$1.09 mcf subsidy

Capture Costs

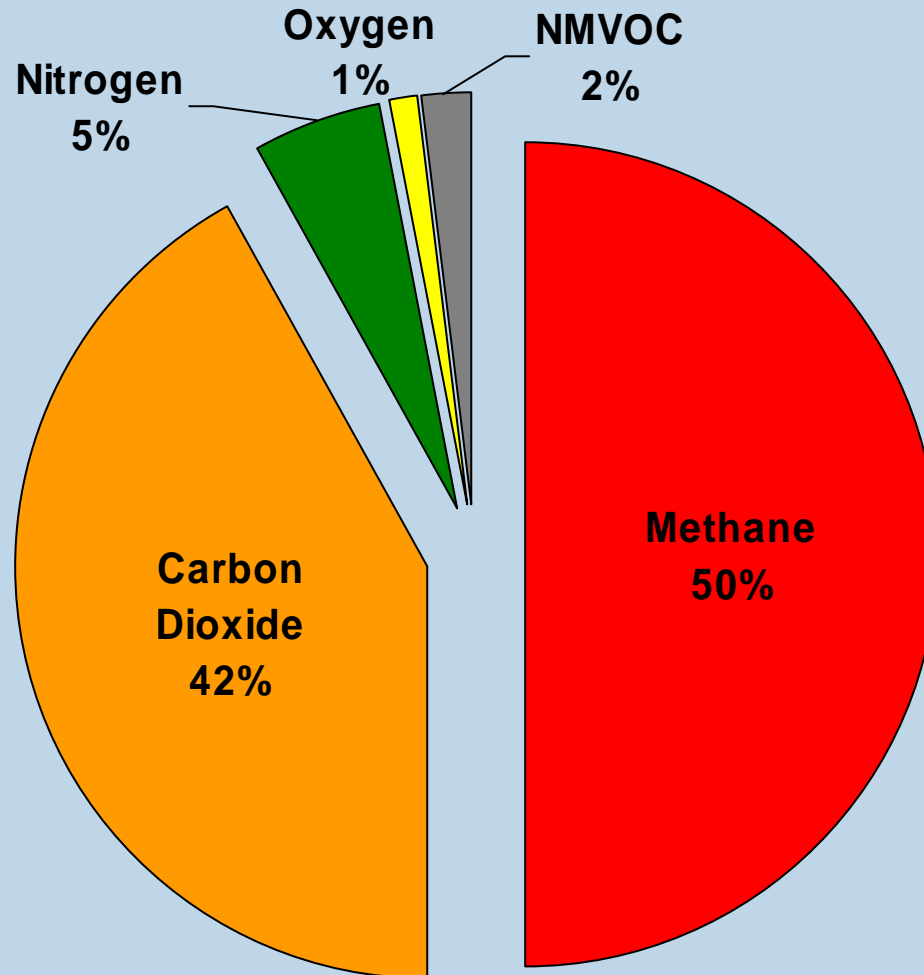
- ★ 12-15 Cents/Kwh
Assuming 33% efficiency

Deffenbaugh Facility

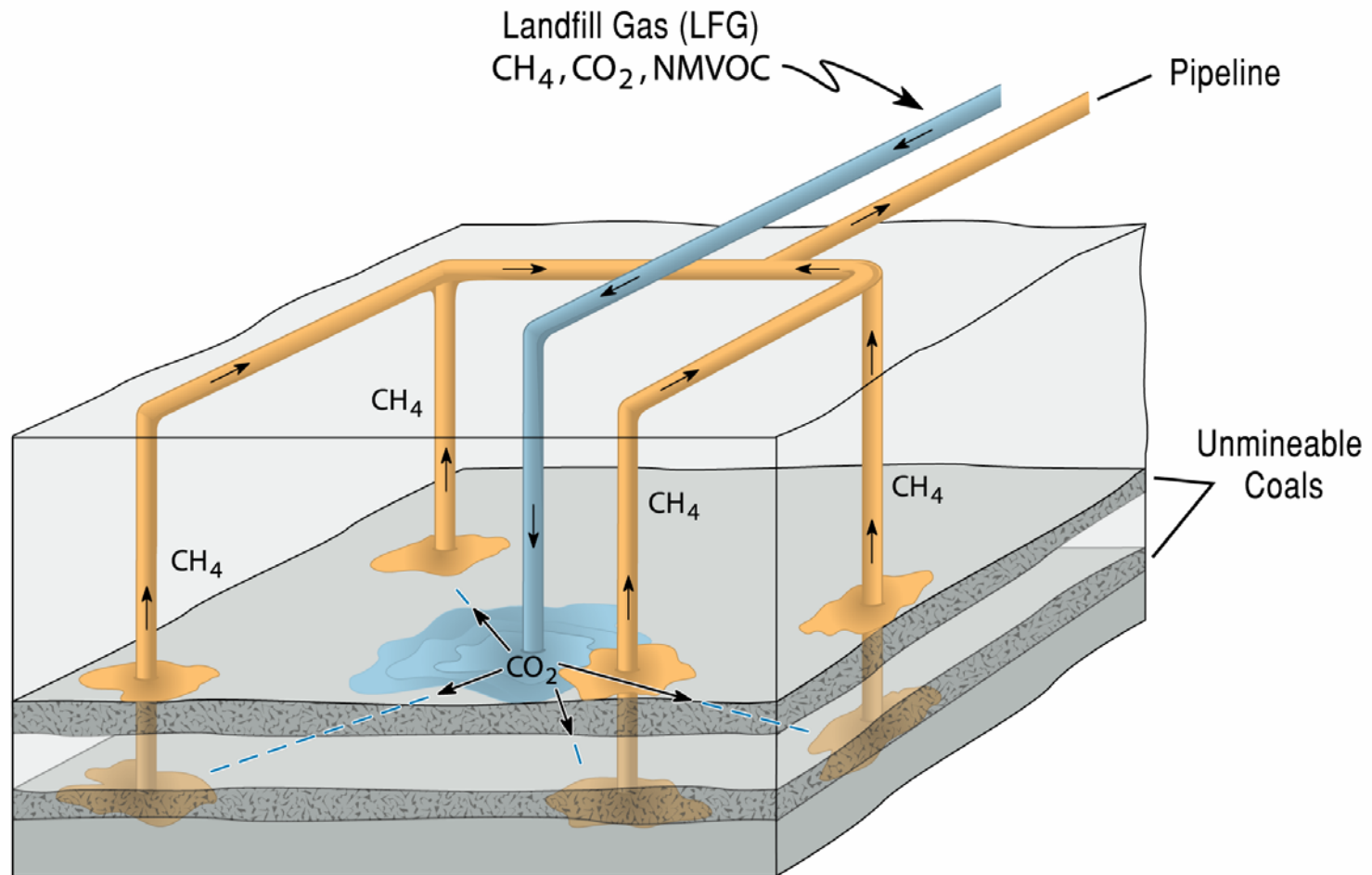
- ★ LFG 4.5 mmcf/day
54 mmcf CO₂ equiv.
- ★ CH₄ 1.8 mmcf/day sold
- ★ 116 tons CO₂ and NMVOC vented per day



Landfill Gas



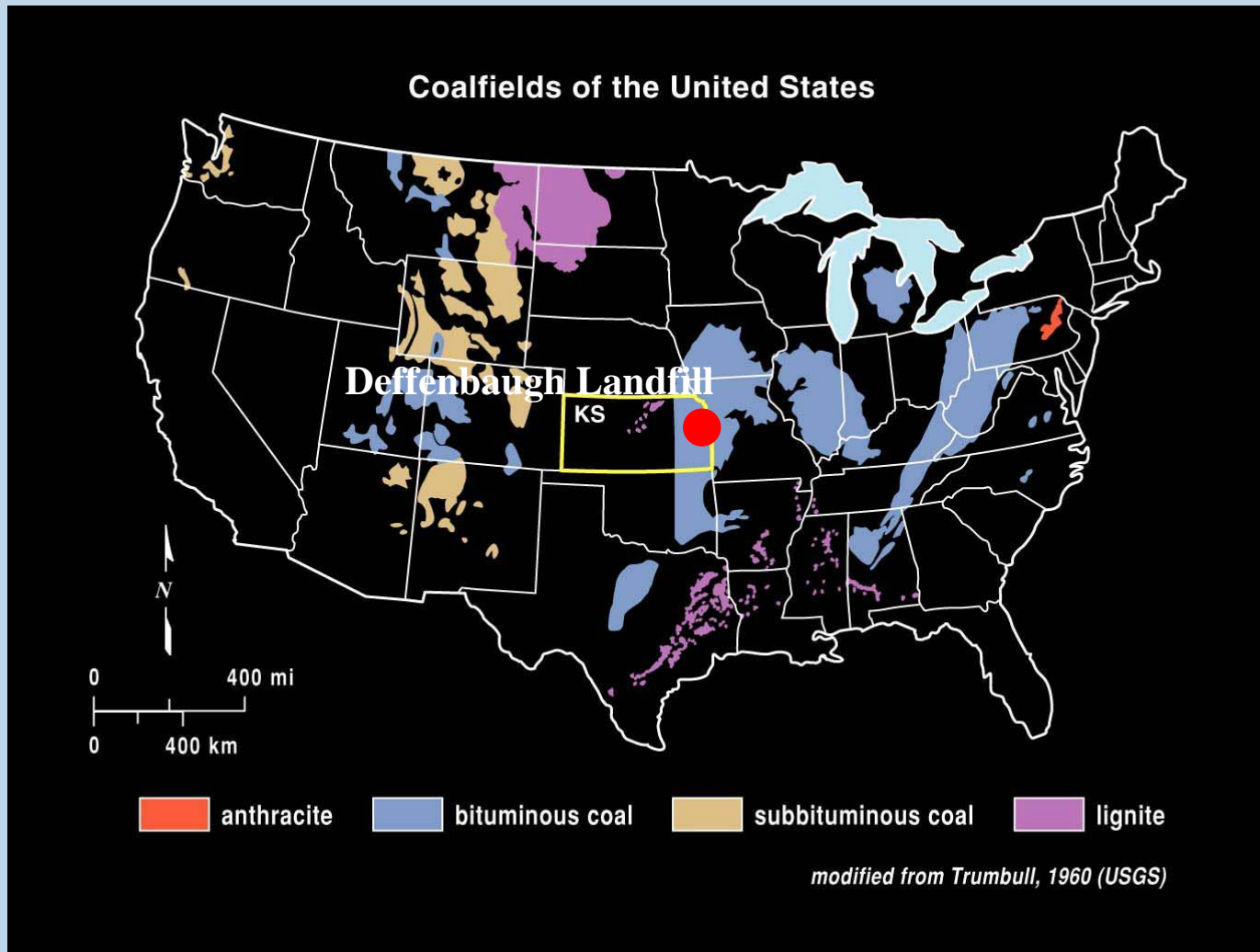
Landfill Gas



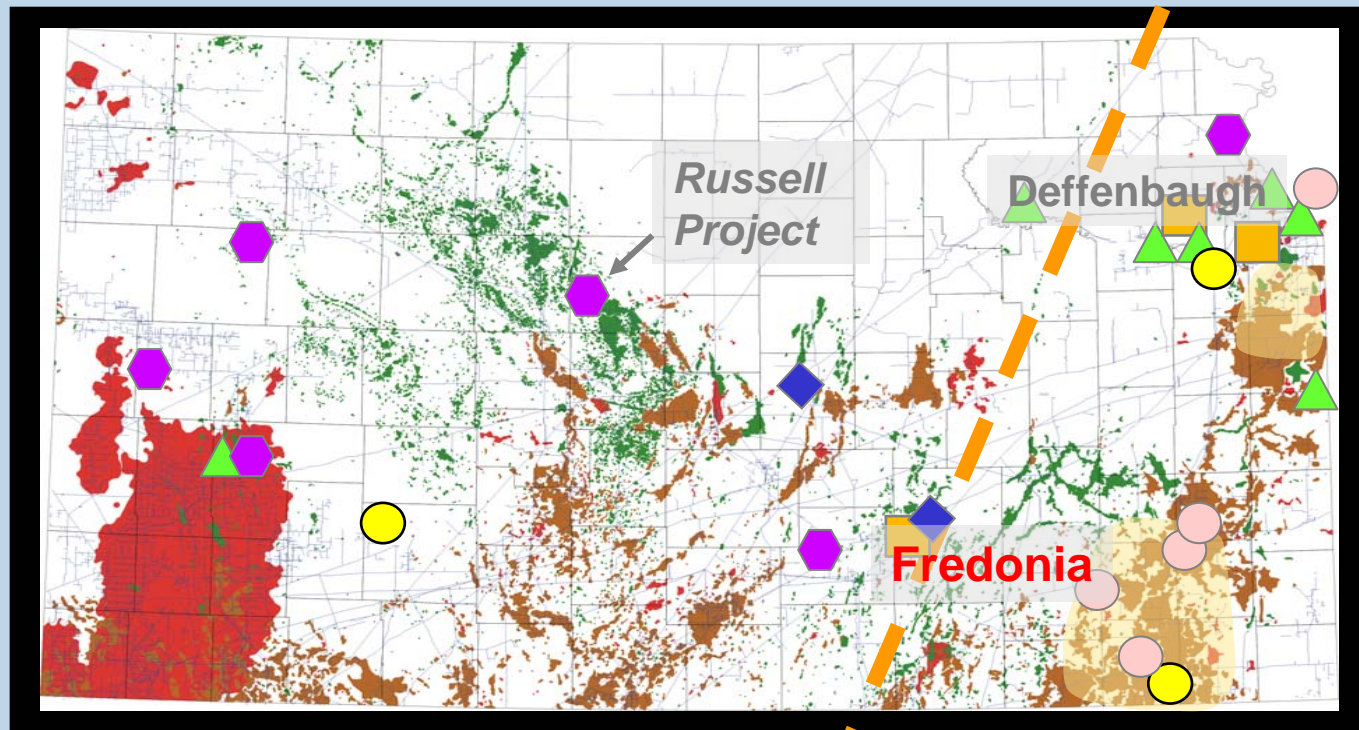
Landfill Gas



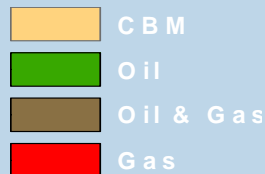
Landfill Gas



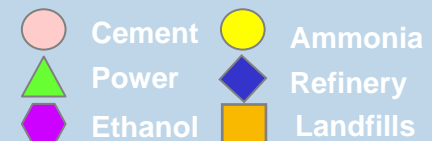
Major Kansas GHG Sources



**Oil and
Gas
Fields**

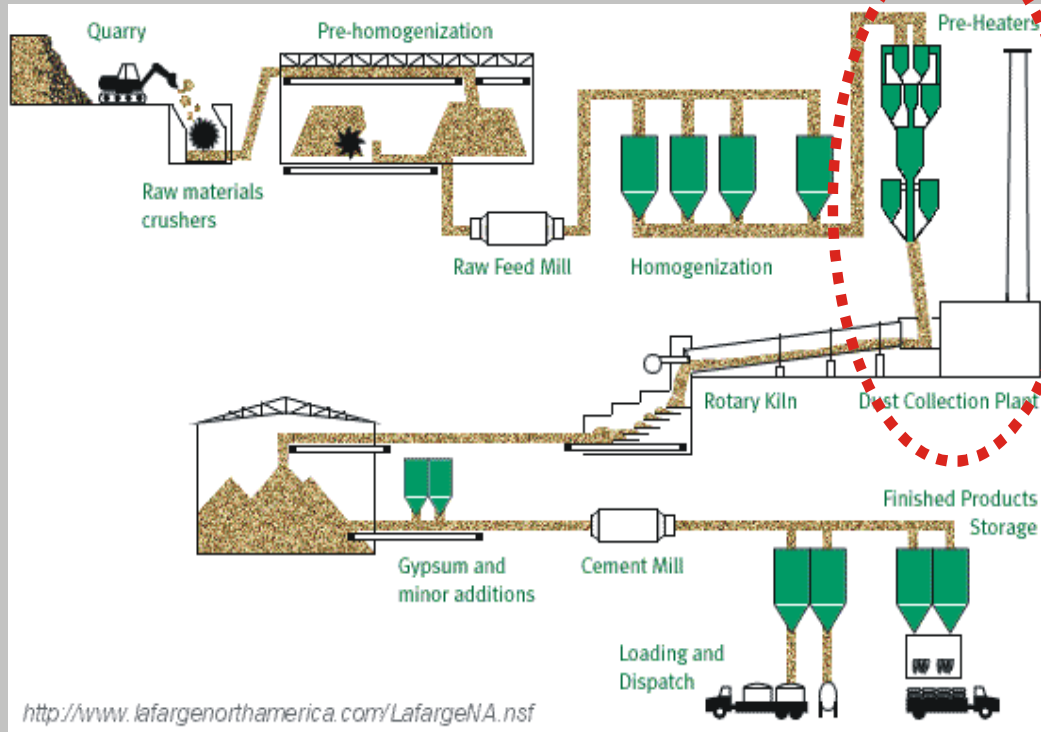


Industry



Cement Production

Dry Kiln Portland Cement Process



Calcination Process
 $\text{CaCO}_3 \rightarrow \text{CaO} + \text{CO}_2$
0.51 tons CO₂ / ton
cement

CO₂ and N₂ kiln gas
mix may be suitable
for ECBM with little
processing

Fredonia Flue Gas and Potential SE Kansas Markets

Present Composition

	% Weight
N ₂	47.3%
H ₂ O	22.6%
CO ₂	19.3%
O ₂	10.6%
	99.8%

5000 tons/day at
332° F (167° C)

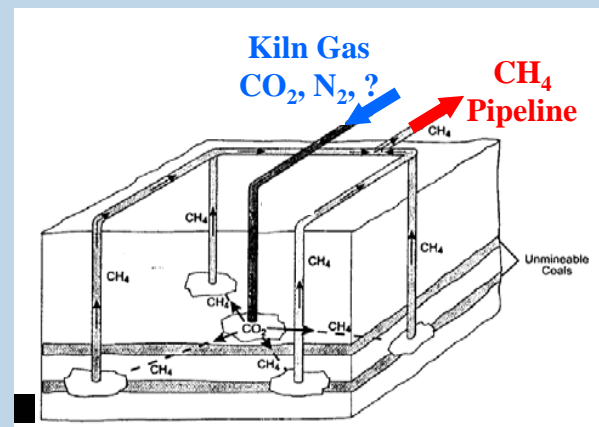
Dehydrate

	% Dry Weight	% Dry Volume
N ₂	61%	69%
CO ₂	25%	18%
O ₂	14%	13%

Reduce
Air Leaks

	% Dry Weight	% Dry Volume	Annual Vol.
N ₂	46%	57%	8.1 BCF
CO ₂	50%	39%	5.7 BCF
O ₂	4%	4%	0.6 BCF

Enhanced Coalbed Methane (ECBM)

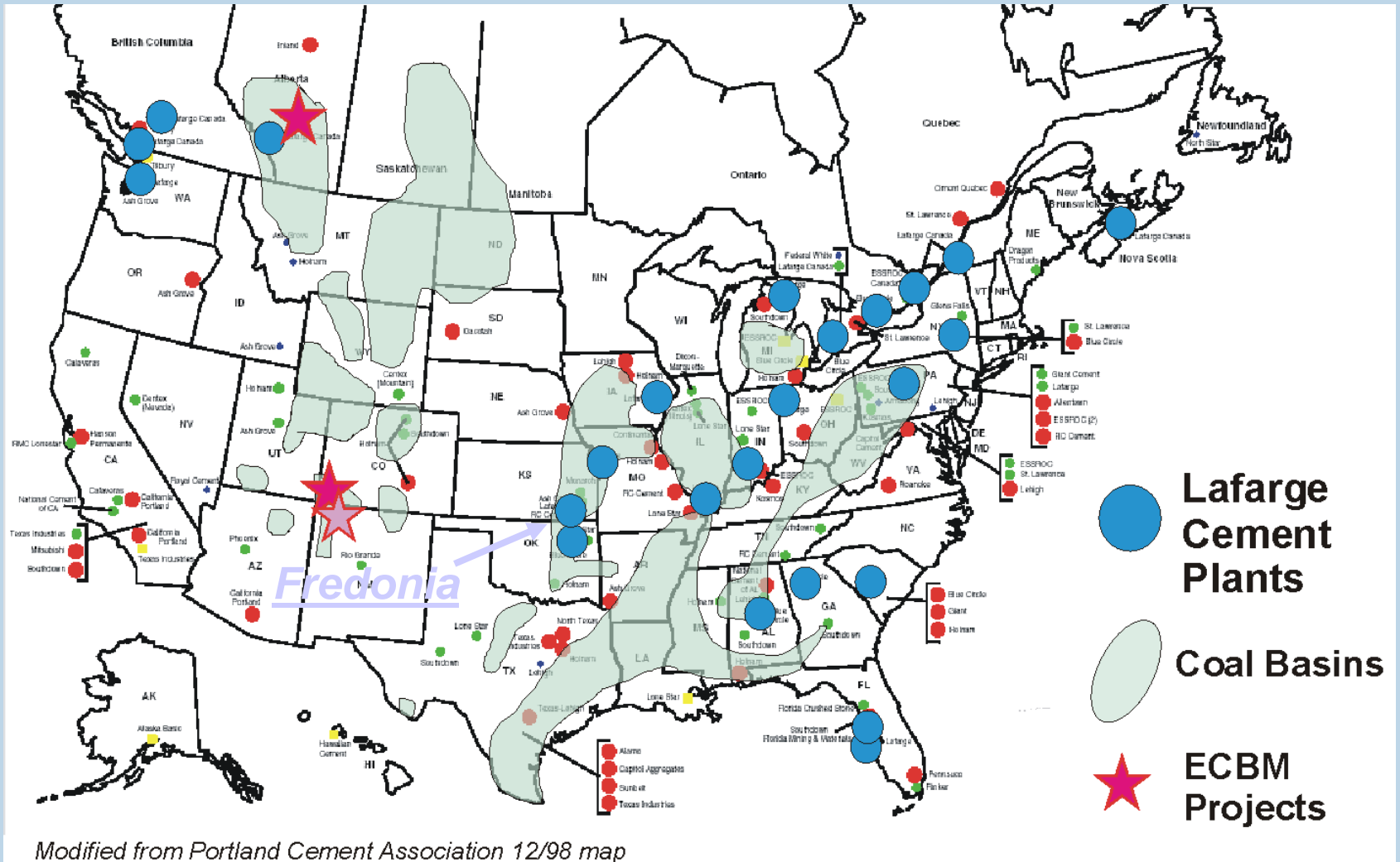


Direct or Modified

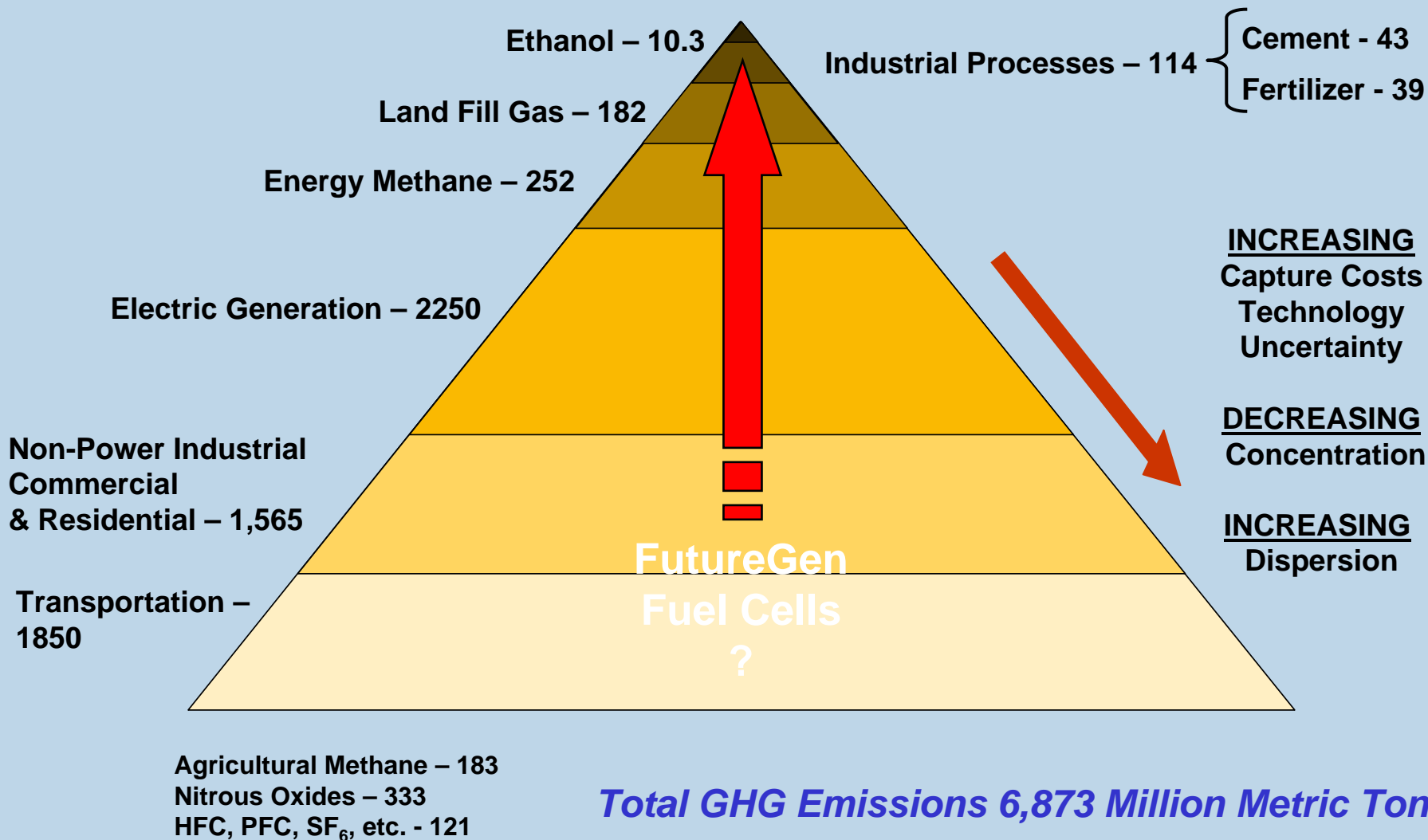
Co-generation

400°C

Cement Plants and Coal Basins

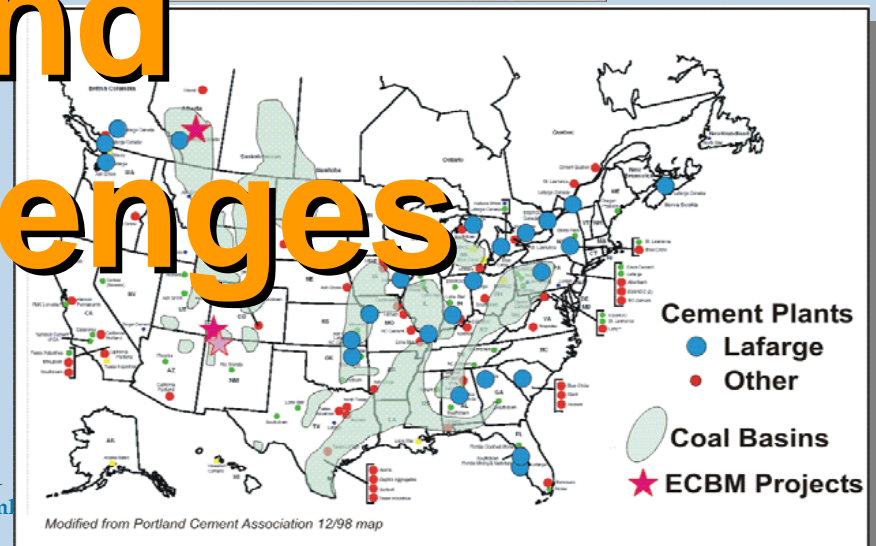
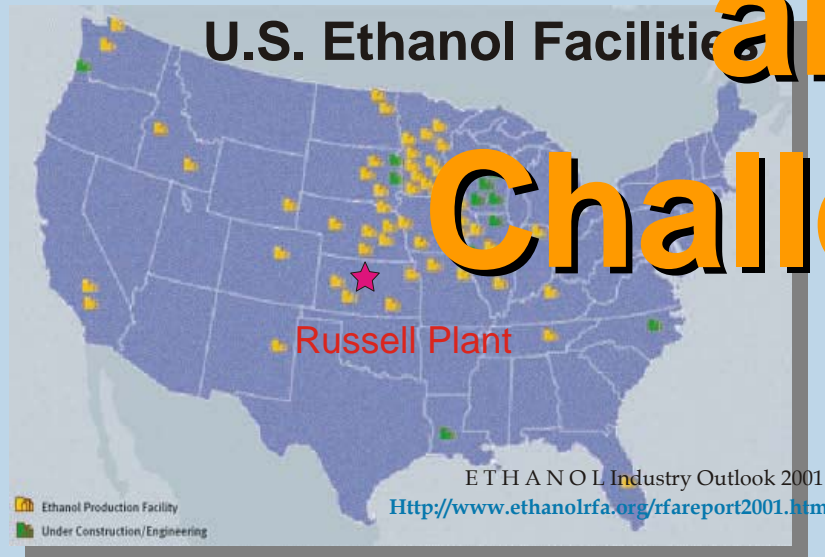
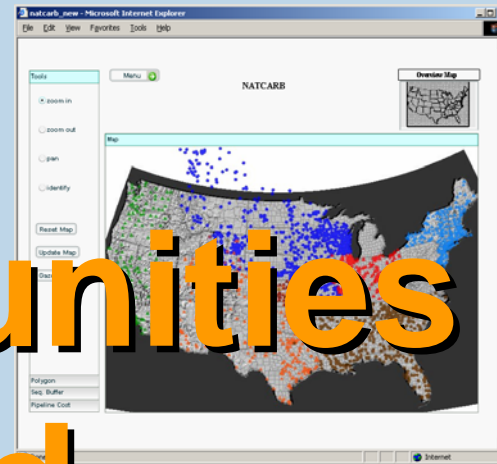
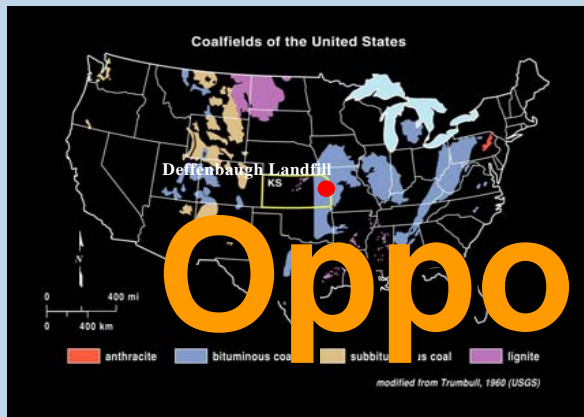


Greenhouse Gas Resource



Data: Year 2002 Energy Information Agency and Renewable Fuels Assos.

Potential Energy Systems



Kansas Approach

- **Expand the number and type** of carbon sequestration opportunities in Kansas
- **Lower the cost** and optimize the value-added benefits associated with CO₂ storage
- **Develop field and management practices** to minimize seepage and promote permanence
- **Develop capability to assess** capacity for carbon storage

Partners

- US Department of Energy
- Oak Ridge National Laboratory
- Carbon Sequestration Partnerships
- University of Kansas
- State of Kansas
 - Department of Commerce, KTEC
- Industry
 - MV Energy Partners, J. O. Farmer, White Eagle Resources
 - Trenton Agri Products, BEREXCO
 - ICM / US Energy Partners
 - EPCO, Kinder Morgan
 - Lafarge NA
 - Deffenbaugh Industries, SouthTex Treaters
 - Blue Source, Ecology and Environment
 - NPPD, OPPD, Xcel, Entergy